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(54) Bezeichnung: Verfahren und Vorrichtung zum formhaltigen Kühlen von Flachglas

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(56) Für die Beurteilung der Patentfähigkeit in Betracht gezogene Druckschriften:

DT-PS	2 19 329
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US	32 38 033

EICHNUNGEN BLATT 1

Nummer: 21 58 25
Int. Cl.²: C 03 B :
Bekanntmachungstag: 23. Sept

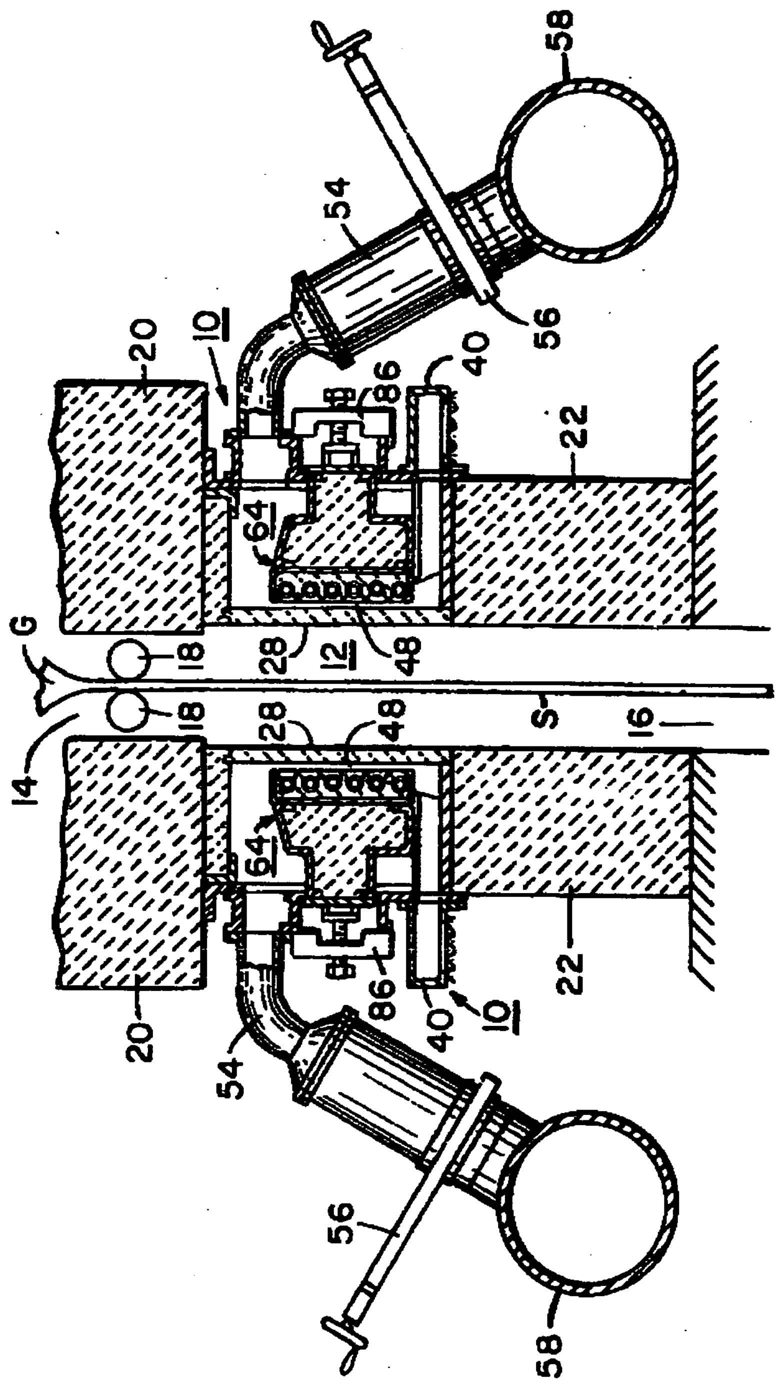

Fig. 1

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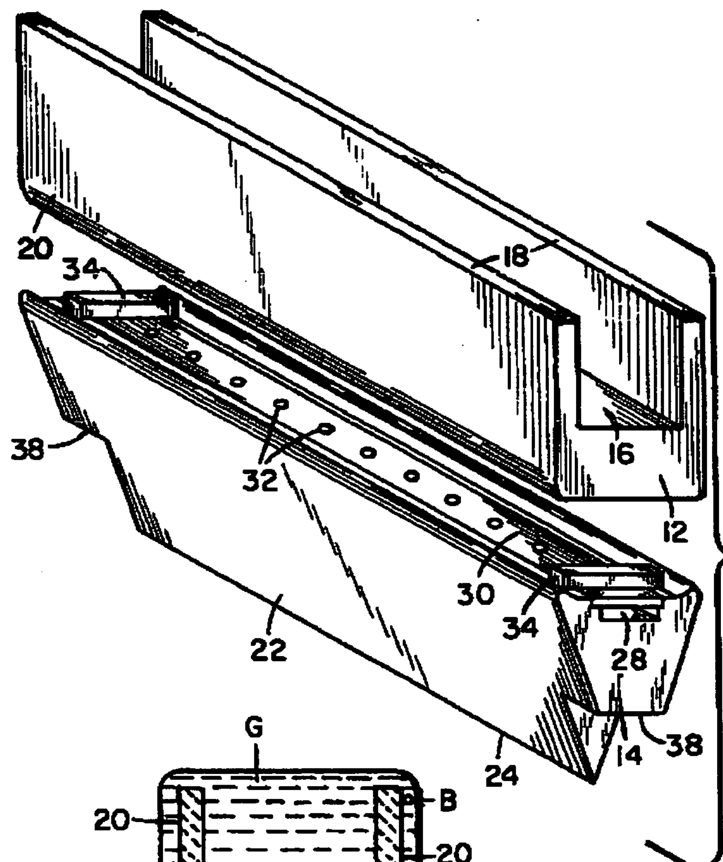

Fig. 2

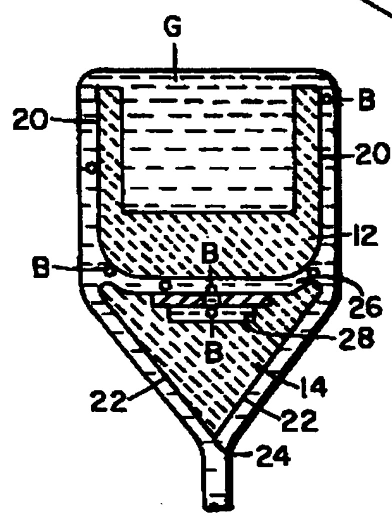

Fig. 3

Patentansprüche:

1. Verfahren zum raschen Abkühlen frisch aus einer Glasschmelze in eine Formzone und von da bei noch hoher Temperatur in eine Übergangszone gezogenem Glas in Form von Tafeln, Bändern u. dgl. bis zur Formhaltigkeit über die gesamte Glasbreite unter Berücksichtigung unterschiedlicher Dicke, dadurch gekennzeichnet, daß ein sich aus mehreren über die gesamte Glasbreite reichenden, unabhängig voneinander einzeln regelbaren Strömungen zusammensetzender, mit hoher Geschwindigkeit längs zur Ziehrichtung gleichsinnig oder entgegengesetzt fließender Kühlmittelstrom unabhängig von der Einzelregelung auch in seiner Gesamtgeschwindigkeit regelbar ist.

2. Vorrichtung zur Durchführung des Verfahrens gemäß Anspruch 1, dadurch gekennzeichnet, daß ein dem frisch gezogenen Glas gegenüberliegendes Gehäuse (10) eine Wand (28) aus einem Material großer Wärmeleitfähigkeit, niedriger Wärmedehung und starker Wärmeabstrahlung von der Rückseite aufweist, deren Rückseite eine veränderliche Durchlaßspalte (48) für den Kühlmittelstrom über die gesamte Glasbreite begrenzt.

3. Vorrichtung gemäß Anspruch 2, dadurch gekennzeichnet, daß die Änderung der Gesamtgeschwindigkeit über eine die Einzelleitungen für die Einzelströmungen versorgende Sammelleitung erfolgt.

4. Vorrichtung gemäß Anspruch 2, dadurch gekennzeichnet, daß die Änderung der Gesamtgeschwindigkeit durch Veränderung der Breite der Durchlaßspalte vorgenommen wird.

5. Vorrichtung gemäß Anspruch 4, dadurch gekennzeichnet, daß die Breitenänderung der Durchlaßspalte durch Verschieben von Heizmittel (72) für die Übergangszone tragenden Heizblöcken (64) auf Schienen (56) vorgenommen wird.

Die Erfindung betrifft ein Verfahren und eine Vorrichtung zum raschen, steuerbaren, gleichmäßigen Abkühlen von frisch aus der Schmelze gezogenem Flachglas, wie Glastafeln, Glasband u. dgl. bis zur Formhaltigkeit.

Beim Ausziehen von Flachglas aus einer Schmelze muß das als Tafel, Band u. dgl. frisch gezogene Glas gekühlt und seine Viskosität so weit erhöht werden, daß es beim Ziehen nicht reißt und seine Form behält.

Zur Erzielung einer gleichmäßigeren Dicke des noch weichen Glasbands sind Vorrichtungen bekannt, welche während des Ziehens die Banddicke in Querrichtung messen und bei Abweichungen die Wärmezufuhr entsprechend erhöhen, z. B. durch jeweils quer über die gesamte Bandbreite verlaufende, einzeln regelbare Heizer (DT-PS 12 25 826). Hierdurch soll quer zur Ziehrichtung die Glasdicke gesteuert werden, das Problem der gleichmäßigen, raschen Verfestigung bis zur Formhaltigkeit wird hierdurch aber noch nicht einwandfrei gelöst.

Für die Erstarrung der Glasmasse bis zur Reißfestigkeit und Formhaltigkeit des gezogenen Glases wurde bisher meist die ganze Tafel mit einem Luftstrom oder durch der Glasfläche gegenüberliegende Wasserkühler gekühlt (US-PS 32 23 502). Hierbei entstehen aber eine ungleichmäßige Abkühlung verursachende Strömungen; insbesondere können durch Konvektionsströmungen an den Wänden der Kühlgehäuse kaminartige, ungleich kühlende Strömungen entstehen. Dadurch können nicht nur spannungserzeugende Bereiche ungleichmäßiger Verfestigung entstehen, sondern es kann darüber hinaus die im weichen Glasbereich vorgenommene, gesteuerte Wärmebeaufschlagung und die dadurch angestrebte Gleichmäßigkeit der Dicke der Glastafel wieder verloren gehen.

Zur Erzielung einer gleichmäßigeren Kühlung schlägt die DT-PS 12 25 827 einen Behälter für die Kühlflüssigkeit mit einem Überzug aus einem fein verteilten, gesinterten, stark wärmeabsorbierenden, feuerfesten Material vor. Hierdurch wird zwar eine Wärmereflexion durch Metallteile des Gehäuses auf das Glasband vermieden, jedoch besteht immer noch die Gefahr ungleichmäßiger Kühlung durch unterschiedliche Wassertemperaturen am Einlaß- bzw. Auslaßende des Gehäuses. Auch sind der für eine rasche, formhaltige Verfestigung erforderlichen Kühlgeschwindigkeit Grenzen gesetzt.

Zur Vermeidung der eine ungleichmäßige Kühlung bedingenden kalten Luftströmungen wird diese Kaltluft nach dem Vorschlag der US-PS 32 38 033 durch Öffnungen in der dem Glasband gegenüberliegenden Wärmeaustauschfläche abgesaugt. Jedoch erscheint es günstiger, unerwünschte Konvektionsströmungen möglichst gar nicht erst entstehen zu lassen und die Glastafel so rasch und gesteuert zu kühlen, daß entweder bereits ausgeglichene Dickenänderungen nicht wieder entstehen, oder in diesem Stadium so berücksichtigt werden, daß die ganze Tafel rasch und gleichmäßig formhaltig und reißfest ziehbar verfestigt wird.

Die Erfindung hat zur Aufgabe, dies zu erreichen. Zur Lösung dieser Problemstellung sieht das Verfahren der Erfindung vor, daß ein sich aus mehreren über die gesamte Glasbreite reichenden, unabhängig voneinander einzeln regelbaren Strömungen zusammensetzender, mit hoher Geschwindigkeit längs zur Ziehrichtung gleichsinnig oder entgegengesetzt fließender Kühlmittelstrom unabhängig von der Einzelregelung auch in seiner Gesamtgeschwindigkeit regelbar ist.

Zur Durchführung dieses Verfahrens bringt die Erfindung eine Vorrichtung in Vorschlag, in welcher ein dem frisch gezogenen Glas gegenüberliegendes Gehäuse eine Wand aus einem Material großer Wärmeleitfähigkeit, niedriger Wärmedehnung und starker Wärmeabstrahlung von der Rückseite aufweist, deren Rückseite eine veränderliche Durchlaßspalte für den Kühlmittelstrom über die gesamte Glasbreite begrenzt. In den Zeichnungen zeigen

Fig. 1 eine die erfindungsgemäße Vorrichtung enthaltende Glasziehvorrichtung in Frontansicht und teilweise im Schnitt in der Übergangszone,

Fig. 2 im Schnitt eines der Gehäuse mit der erfindungsgemäßen Vorrichtung,

Fig. 3 das Gehäuse der Fig. 2 in Seitenansicht,

Fig. 4 die gegenüberliegenden Gehäuse in Aufsicht.

In der Fig. 1 sind in der zwischen der Glastafelformzone 14 und der Anlaßzone 16 liegenden Übergangszone 12 die gegenüberliegenden, luftgekühlten Gehäuse 10 angeordnet. In der Formzone wird geschmolzenes Glas *G* durch eine Formöffnung oder über einen Formkeil mit geeigneten Kantenrollen 18 zu einer Glastafel *S* ausgezogen. Meist sind die feuerfesten Gehäuse 20 um die Formzone 14 mit zusätzlichen Kühlern versehen, um eine gleichmäßige Stärke über die gesamte Tafelbreite

zu erzielen, solange das Glas noch geschmolzen oder teils geschmolzen ist.

Obgleich die Dicke der frischen Glastafel *S* in der Formzone festgelegt wird, muß in der Übergangszone eine ausreichende Menge Wärmeenergie von der Glastafel abgezogen werden, damit das Glasband beim Eintreten in weitere Zonen, insbesondere in die Anlaßzone 16 und beim erneuten Erhitzen intakt bleibt. Der Träger aus feuerfestem Material 22 kann ebenfalls hohl ausgebildet und mit Kühlmitteln versehen sein.

Möglich ist auch die Ausbildung des Trägers als ein weiteres Übergangsgehäuse 10, da sich bei mehreren, übereinander gestapelten mit getrennter Temperaturregelung versehenen Gehäusen die Notwendigkeit eines gesonderten Anlaßofens erübrigt.

Die beiden gegenüberliegenden Übergangsgehäuse 10 der Fig. 1 sind einander gleich, so daß nur eines beschrieben wird. Es wird von einem Traggerüst 24, 26 abgestützt und besteht aus der Stirnwand 28, der Decke 30, dem Boden 32, der Rückwand 34, den Endblöcken 36 (Fig. 4) und bildet eine Durchlaßspalte 38 für das Kühlmittel. Wie die Pfeile der Fig. 2 andeuten, wird das Kühlmittel, z. B. Luft durch eine mit einem Drahtmaschenfilter 42 versehene Einlaßsammelleitung 40, die an einer Konsole 46 der Rückwand 34 befestigt ist und mit ausgerichteten, durch die Konsole und die Rückwand gehenden Einlaßöffnungen 44 verbunden ist, in das Gehäuse 10 gesaugt und strömt durch die Durchlaßspalte 38 und die in der Konsole 46 und der Rückwand 34 angebrachten Auslaßöffnungen 50 wieder aus.

Durch die Abteilungen 52 der Konsole 46 werden entlang der Rückseite der Gehäuse 10 mehrere, z. B. fünf an Auslaßleitungen 54 angeschlossene Auslaßöffnungen 50 gebildet. Die Auslaßleitungen 54 enthalten zweckmäßig die zur Vereinfachung der Zeichnung nur in der Fig. 1 gezeigten Regelventile oder -schieber 56 und sind an eine mit einem Hauptregelventil oder -schieber 60 ausgestattete Auslaßsammelleitung 58 angeschlossen. Die Luft wird z. B. durch eine an die Sammelleitung 58 angeschlossene Saugpumpe oder ähnliche, ein Teilvakuum erzeugende Vorrichtung, durch das Gehäuse 10 gefördert.

Das Gehäuse 10 enthält auf den Schienen 66 verschiebbare Heizblöcke 64. Diese bestehen aus dem feuerfesten Körper 68 in einem Metallgehäuse 70, mit einem, mit den in Isolatoren 76 angeordneten Heizelementen 74 versehenen vorderen Teil 72, und einer über die gesamte Breite reichenden Rückenplatte 78 mit einem Paar Stellblöcken 80, die je einen Haltering 82 mit einer Einstellschraube 84 tragen. Ein fester Block 86 ist an der Konsole 46 befestigt und mit den Stellblöcken 80 ausgerichtet. Eine der Stellschrauben ist in den Block 86 geschraubt, so daß die Blockanordnung 64 entlang den Schienen zur Veränderung der Spaltbreite der Spalte 48 und damit der Geschwindigkeitsänderung des Luftstroms verschoben werden kann.

Die Arbeitsweise ist folgende. Aus der Glasschmelze *G* wird in der Formzone 14 die Glastafel *S* gezogen und mit den Kantenrollen 18 weiter in die Übergangszone 12 gefördert. Hier wird der Glastafel ein erheblicher Teil Wärmeenergie entzogen, so daß sie weitgehend erstarrt und bei der Weiterbeförderung in die Anlaßzone 16 ihre Form beibehält.

Durch das Gebläse 62 wird bei entsprechender Einstellung des Hauptventils 60 normalerweise ein Unterdruck in der Sammelleitung 58 erzeugt, so daß durch die Sammelleitung 40 und die Einlaßöffnungen 44 Luft in das Gehäuse gesaugt wird, die längs zur Glasziehrichtung durch die Spalte 48 entlang der z. B. aus Siliziumcarbid bestehenden Stirnwand über die Auslaßöffnungen 50 und Leitungen 54 wieder ausströmt. Da jede Auslaßleitung 54 mit einem Regelventil 56 versehen und mit einer über eine bestimmte Breite bzw. ein Segment des Gehäuses reichenden Auslaßöffnung 50 verbunden ist, kann der die einzelnen waagerechten Teilflächen der Stirnwand 28 bestreichende Luftstrom für jeden Bereich einzeln eingestellt und geregelt werden. Damit ergibt sich die Möglichkeit, z. B. die meist stärkeren Kanten oder Randteile der Glastafel stärker und damit das gesamte Glastafelvolumen gleichmäßig zu kühlen. Hierzu werden z. B. die Ventile 56 der die Tafelränder bestreichenden Leitungen 54 weiter geöffnet als die übrigen Ventile. Andere Möglichkeiten, unterschiedliche Kühlmittelgeschwindigkeiten einzustellen, ergeben sich dem Fachmann. Die verschiedensten Glasformen sind hierdurch gleichmäßig kühlbar, wie z. B. keilförmige Glasbahnen, die an der Keilbasis stärker gekühlt werden müssen.

Durch den Kühlmittelstrom wird der Stirnwand 28 und dadurch der Glastafel Wärme entzogen. Die Stirnwand besteht daher zweckmäßig aus einem Material hoher Emissivität, so daß es die von der Glastafel abgestrahlte Wärme gut absorbiert; hoher Wärmeleitfähigkeit, so daß die absorbierte Wärmeenergie rasch auf die Rückseite der Stirnwand geleitet und vom Kühlmittel aufgenommen werden kann; und niedriger Wärmedehnung, um gegenüber der Glastafel eine ebene, verwerfungsfreie Glasfläche zu behalten.

Die Breite der Durchlaßspalte 48 in dem Raum 38 des Gehäuses 10 ist einstellbar, z. B. durch Verschieben der Blockanordnung 46 entlang den Schienen 66 vermittels der Stellschrauben 84. Damit ist die Strömungsgeschwindigkeit des die Rückseite der Stirnwand 28 bestreichenden Kühlmittels regelbar, z. B. zwecks Anpassung an verschiedene Glasziehgeschwindigkeiten. Eine weitere Regelung ist durch Einstellung des Hauptventils 60 möglich.

Der nicht unbedingt erforderliche, aber günstige Heizer 72 kann durch Betätigung der Heizelemente 74 die Übergangszone z. B. zur Einbringung des Glasbands bei Beginn der Arbeit, oder im Falle eines Bandrisses beheizen.

Die beispielsweise für das Abwärtsziehverfahren beschriebene Erfindung ist entsprechend im Aufwärtsziehverfahren anwendbar.

Die Verwendung des Unterdrucks ist zwar besonders günstig, weil ohne weiteres der das Glas unter Umständen beschädigende Luftablaß in die Übergangszone vermieden wird. Bei entsprechenden Vorsichtsmaßregeln kann aber auch Überdruck verwendet werden.

Ferner kann der Durchfluß auch gleichsinnig anstatt im an sich bevorzugten Gegenstrom erfolgen. Da die Übergangsgehäuse getrennt regelbar sind, können auch mehrere Übergangsgehäuse zu beiden Seiten der Glastafel übereinander gestapelt werden und bewirken dann z. B. gleichzeitig das Anlassen des Glases.

Hierzu 3 Blatt Zeichnungen

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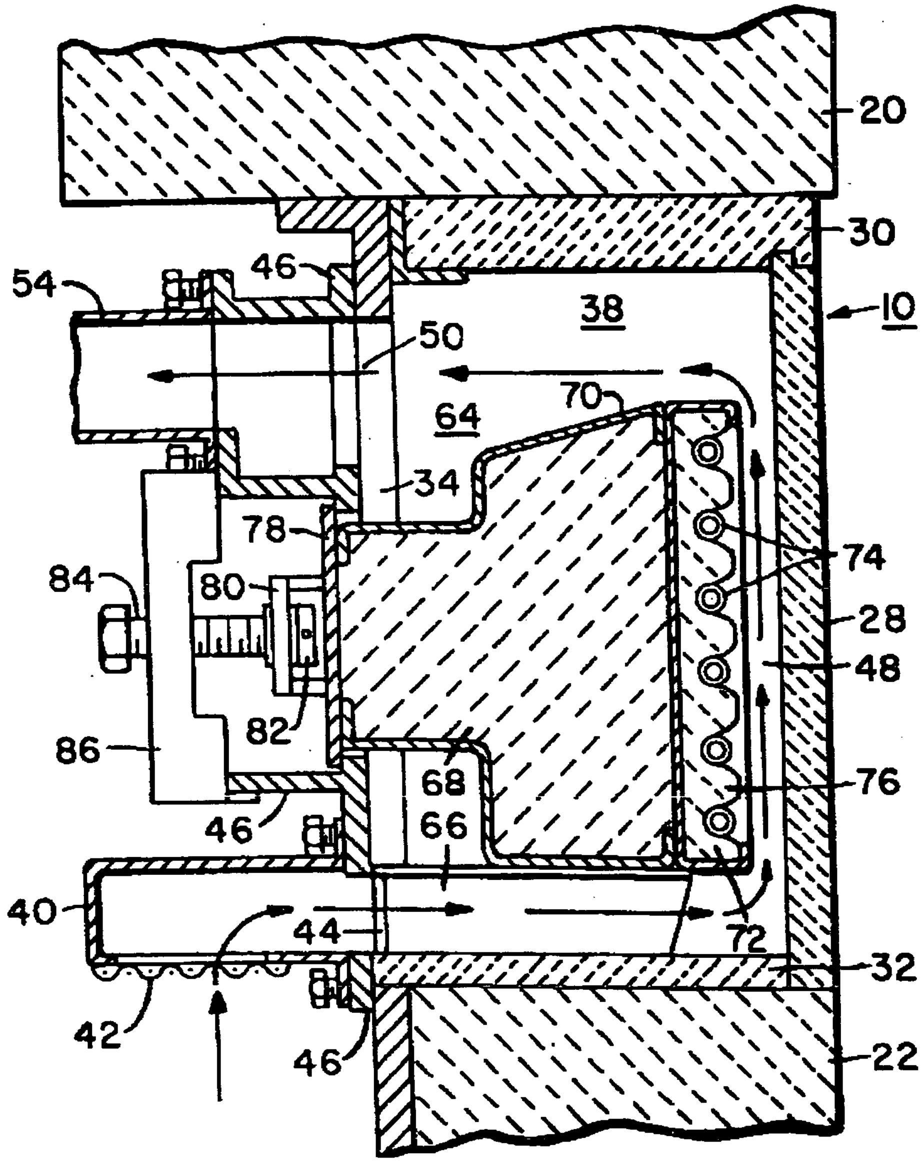

Fig. 2

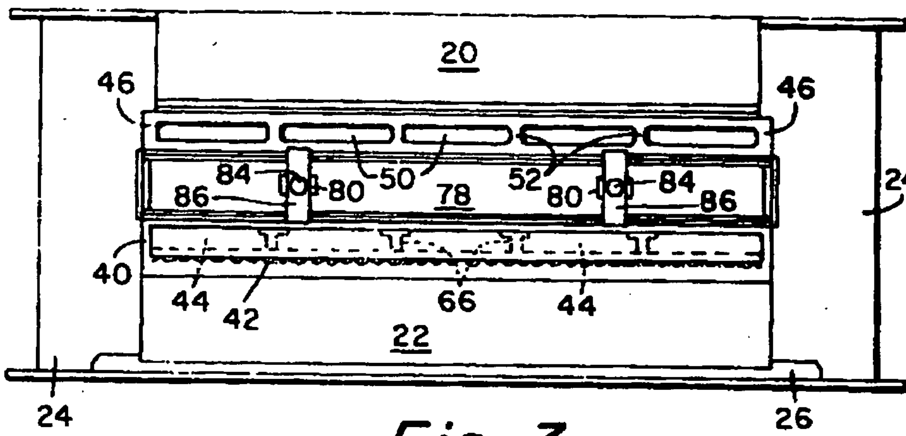
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Fig. 3

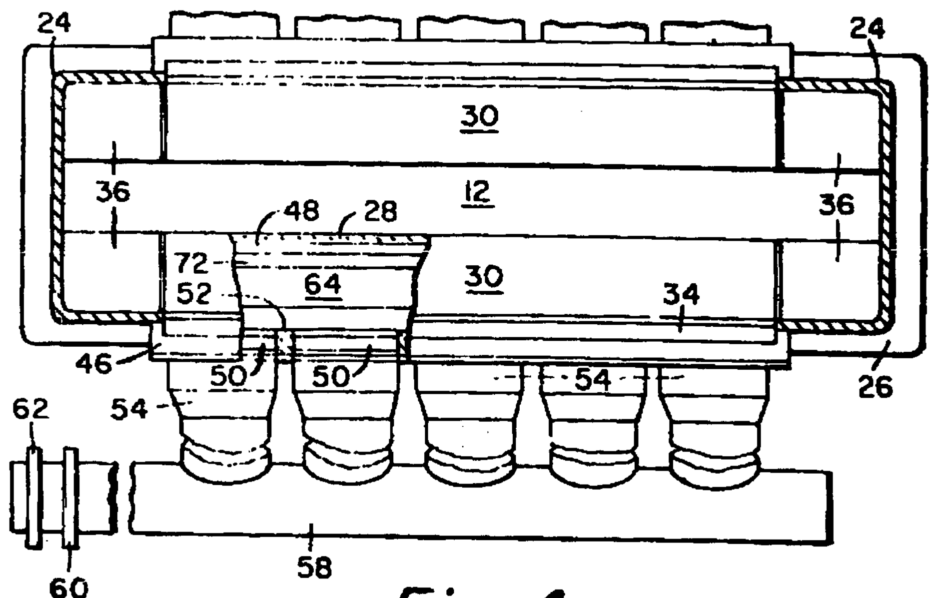
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Fig. 4

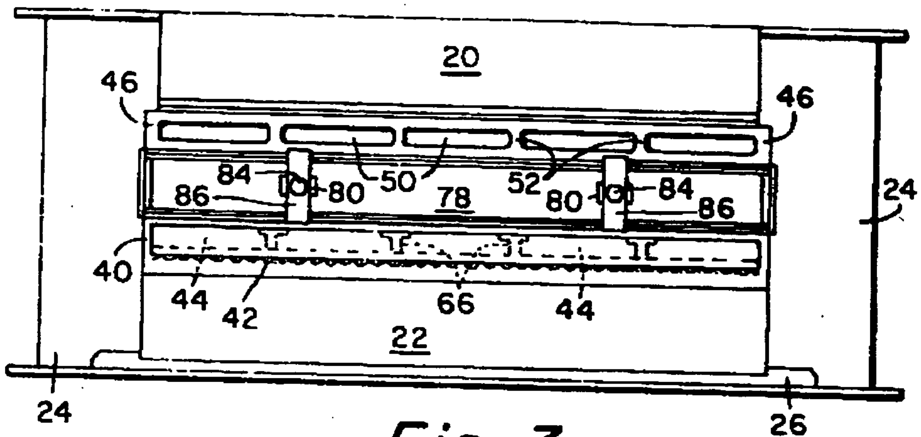
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Fig. 3

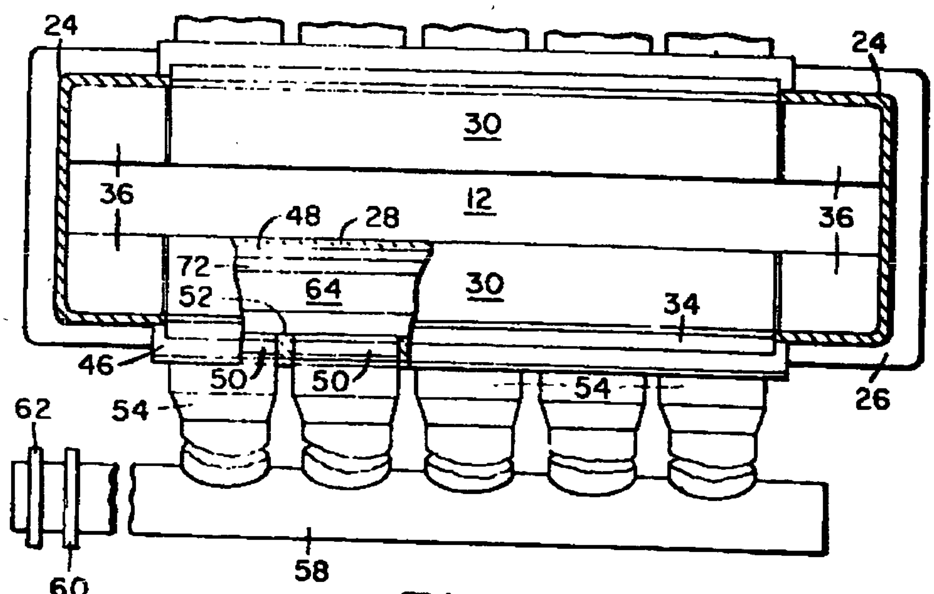
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Fig. 4

PATENT SPECIFICATION (11) 1 354 006

1 354 006

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(31) Convention Application No. 93001 (32) Filed 27 Nov. 1970 in

(33) United States of America (US)

(44) Complete Specification published 22 May 1974

(51) International Classification C03B 17/00 15/02

(52) Index at acceptance

C1M 3A 3B1 D10 D11 D2 D3 D8 S16

(54) COOLING OF SHEET GLASS

(71) We, CORNING GLASS WORKS, a corporation organised under the laws of the State of New York, United States of America, of Corning, New York, 14830, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the cooling of sheet glass.

When forming sheet material from molten glass it is necessary to increase the viscosity of the molten glass by reducing its temperature in order to maintain the integrity of the newly formed sheet. In the formation zone, in which the molten glass is still in a fluid state adjacent the point of draw, it is a known expedient selectively to apply cooling in small increments across the width of the sheet in order to reduce thickness variation within the glass. However, the purpose of such cooling is not rapidly to extract heat in order to set up and maintain the integrity of the newly formed sheet, but rather selectively to cool small designated areas in order to provide a more uniform thickness distribution across the width of the sheet, such as shown by the bayonet coolers of U.S.A. Patent Specification No. 3,223,502.

After the newly formed sheet is withdrawn from the forming zone, which may include a debiteuse block or draw bar in an updraw or a discharge orifice or forming wedge in a downdraw, it is customary to apply generalized cooling to the sheet in a transition zone prior to conveying the sheet to an annealer. However, the known methods and apparatus at present being utilized have not been entirely satisfactory since the direct application of cooling air or other gases to the sheet produces undesirable air flows and convection currents which result in uneven cooling across the width. Further, air flows along the sheet produce a chimney effect which may even interfere with the normal functions of the forming zone or annealing area.

As shown in previously mentioned U.S.A. Patent Specification No. 3,223,502, as well as U.S.A. Patent Specification No. 2,896,376, the use of water coolers has been employed in the transition zone adjacent the newly formed sheet in order to remove undesirable heat. However, the water cooled containers not only have a tendency to produce uneven cooling across the width of the sheet, since the temperature of the water entering the cooler on one side of the sheet is lower than the temperature of the water leaving the cooler on the opposite side of the sheet, but also the metallic walls of the water coolers tend to create convection currents which produce mild chimney effects and result in uneven cooling across the width of the sheet. In addition, both the total amount of heat which could be removed in a given time period and the control of such removal are limited with the use of the known water cooling techniques.

An object of the present invention is to obviate the problems heretofore encountered in cooling newly formed sheet glass in a transition zone, without inducing convection currents.

According to the present invention there is provided, a method of rapidly and controllably cooling newly formed sheet glass drawn from a melt into a sheet in a forming zone and transferred while still at an elevated temperature to a transition zone wherein a flow of high velocity cooling air is passed within a confined space behind a wall member composed of a material having high thermal conductivity and emissivity and low thermal expansion spaced apart from and extending across the width of the newly formed sheet of glass, the flow of cooling air being in a direction which is longitudinal to the draw of the glass sheet, and in which the rate of air flow can be varied in different segments across the width of the confined space if required.

The invention also provides an apparatus for carrying out this method comprising means for providing a high velocity stream of cooling medium, means for varying the velocity of the stream of cooling medium

[*Price 25p*]

and a housing which is positioned in a transition zone so as to be adjacent a surface of newly formed glass, after it has been removed from a forming area and which has a wall member arranged to face the newly formed sheet glass and which is composed of a material having high thermal emissivity and conductivity, and low thermal expansion, the back surface of the wall member and the housing forming a confined passage for the cooling medium stream across a width commensurate with the width of the newly formed sheet glass.

The invention makes it possible to cool newly formed glass sheet at a significant and controllable rate after such sheet has been removed from its forming area. The rate at which heat is removed from a sheet depends upon the total glass flow in the process and the temperature characteristics across the width of the glass sheet. The wall members may be silicon carbide slabs. The newly formed sheet, which may be in a semi-molten state, radiates heat to the front surface of the silicon carbide slab, and heat is removed from the slab by means of high velocity air passing within the confined space or passage (which may be adjustable) along the backside of the wall member, with the cooling air flowing longitudinally of the draw rather than transversely, as was common in the past.

The total amount of heat removal across the width of the sheet is a function of the velocity of air which passes over the back surface of the silicon carbide slab, and accordingly, the rate of heat extraction in the transition zone may be controlled by regulating the air velocity. Regulation of the velocity may be obtained either by adjusting the width of the flow passage behind the silicon carbide slab or by regulating the overall flow rate applied to the system, such as by means of a main damper or flow control valve. In addition, differential cooling rates across the width of the glass sheet may be obtained through the use of individually controlled dampers or valves positioned within air ducts which are connected to horizontally disposed segments across the width of the air cooled transition housing. In general, due to the characteristics of sheet drawing processes, edge portions of the sheet are generally thicker than central portions, and accordingly it is preferable to provide greater cooling at the edges in order to eliminate undesirable stresses which may cause the sheet to warp or fracture.

The high velocity air for cooling the silicon carbide slabs, is preferably drawn through each transition housing by any suitable means such as an exhaust fan. As a result, the interior of each such housing is maintained at a reduced or negative pressure with respect to the adjacent glass forming area, and accordingly, should an air leak occur in the housing, it will not flow into or disrupt the forming area.

Although the air cooled housings of the present invention are primarily designed for cooling newly formed glass sheet as it passes through the transition zone from the forming area to an annealer, heating elements are provided within the housings to not only facilitate initial start-up operations, but also to help stabilize the draw should a glass break-up occur in the operation.

Reference is directed to our Patent No. 1,277,397 which relates to a method of controlling the thickness across the width of newly formed glass sheet which comprises, directing a plurality of individual gaseous streams toward molten material forming sheet glass, impinging such gaseous streams upon the back surface of an uninterrupted wall member having high thermal conductivity, low expansion and high emissivity positioned between such streams and the newly formed sheet, confining the gas from such streams within a housing to prevent it from contacting the newly formed sheet, and controlling the amount of flow in each such stream across the width of such wall member selectively to remove heat therefrom which has been absorbed from the glass and conducted therethrough to the back surface and provide a uniform temperature profile so as to maintain thickness uniformity across the width of the sheet, and to an apparatus for controlling the uniformity of thickness across the width of newly formed sheet glass which comprises, a housing positioned adjacent molten material forming newly drawn sheet glass, a front wall having an uninterrupted back surface forming a portion of the housing and extending across the effective width of the newly formed sheet, a plurality of fluid conduit tubes extending within the housing and arranged in a row across the width of the front wall, each fluid conduit tube having an outlet end spaced from the back surface of the front wall, manifold means providing a source of gas under pressure to the fluid conduit tubes, means for individually regulating the flow rate of the gas through each fluid conduit tube, the said front wall being formed of a low expansion material having relatively high thermal conductivity and emissivity so as effectively to absorb heat from the newly formed sheet material and conduct such heat through the front wall for dissipation responsive to the control effect provided by individually regulated gaseous streams impinged upon the back surface of the front wall by the fluid conduit tubes.

In the accompanying drawings:

Figure 1 is a somewhat schematic end elevational view in section illustrating the air cooled transition zone of the present in-

vention positioned in a downdraw sheet glass operation.

Figure 2 is a side elevational view of one of the air cooled transition housings shown in Figure 1.

Figure 3 is a side elevational view of the housing structure with the exterior air ducts removed for clarity, and

Figure 4 is a top plan view of the opposed air cooled transition housings, partially cut away.

Referring now to the drawings, and particularly Figure 1, a pair of opposed air cooled transition housings 10 is shown positioned in connection with a downdraw sheet glass forming operation. The housings 10 are positioned in a transition zone 12 intermediate a forming area 14 and an annealing zone 16. Molten glass G in the forming area is fed through an orifice or along a forming wedge and pulled downwardly by suitable edge rollers 18 to form sheet glass S. Customarily, the refractory housings 20 surrounding the forming area 14 are provided with incremental cooling devices so as to effect thickness uniformity across the width of the sheet as it is being formed and while still in a molten or semi-fluid state. Although the thickness characteristics of the newly formed sheet S passing into the transition zone 12 were determined in the forming zone, it is necessary to remove a quantity of heat from the newly formed glass in the transition zone so as to maintain the integrity of the draw as the sheet is fed into further heat treating areas such as annealing zone 16. Refractory support members 22 for the transition housings 10 may also be formed of a hollow construction and provided with cooling means as desired. Support member 22 could in fact take the form of an additional transition housing 10, since it has been found that a plurality of vertically stacked and individually controlled air cooled transition housings 10 can eliminate the need for a conventional annealing zone.

As shown in Figure 1, both of the opposed air cooled transition housings 10 are identical with one another, and accordingly only one such housing will be described in detail. The opposed transition housings 10 may be supported in spaced relationship adjacent the drawn glass sheet by means of a common supporting framework as shown in Figures 3 and 4, comprising upright structural support members 24 and horizontal support frame members 26. As shown particularly in Figure 2, the housing 10, including a front wall 28, a top wall 30, a bottom wall 32, a rear wall 34 and end blocks 36 (shown in Figure 4) provides a confined space 38 for the passage of air therethrough. As shown by the arrows in Figure 2, air is drawn into the housing 10 through an inlet manifold 40 having a wire mesh filter 42. The inlet manifold 40 is connected to a mounting bracket 46 on rear wall 34 and is in communication with aligned inlet openings 44 formed through the mounting bracket and rear wall. The air is drawn through an adjustable gap or passage 48 behind the front wall 28 in a direction longitudinal to the glass draw, and then outwardly from confined space 38 through a plurality of outlet openings 50 formed in mounting bracket 46 and back wall 34.

As shown more particularly in Figures 3 and 4, mounting bracket 46 is provided with a plurality of dividers 52 which form five separate outlet openings 50 across the back of each housing 10. A plurality of exhaust ducts 54 are connected to mounting bracket 46, with one such duct being in communication with each outlet opening 50. Each exhaust duct 54 is provided with an adjustable valve or blast gate 56 (Figure 1). For the sake of clarity, the individual blast gates have not been shown in the ducts 54 of Figure 4. However, as shown in both Figures 1 and 4, the individual exhaust duct 54 of each housing 10 is in communication with a main exhaust header 58, which, as shown in Figure 4, is provided with a main blast gate 60 for controlling the overall flow through the header 58, and a vacuum producing means such as an exhaust fan 62 for pulling the air through the housing 10.

A heater block assembly 64 is shown as being slidably mounted on a plurality of rails 66 within each housing 10. The heater block assembly 64 has a main refractory body portion 68 surrounded by an expanded metal casing 70, and a forward heating portion 72 including a plurality of electrically energizable heating elements 74 positionably retained within a suitable insulating material 76. The heater block assembly 64 is provided with a back plate 78 extending across its width, having a pair of adapter blocks 80 each provided with a retaining ring 82 for rotatably supporting an adjustment screw 84. A rigid block member 86 is secured to mounting bracket 46 in alignment with each adapter block 80 and threadably receives one of the adjustment screws 84, so that the heater block assembly 64 may be adjustably moved inwardly and outwardly within the confined space 38 of housing 10 along slide rails 66 to adjust the thickness of confined passage 48 and accordingly the velocity of air passing therethrough.

Exhaust fan 62 is normally operative to maintain a reduced or sub-atmospheric pressure in headers 58, as determined by the position of main blast gate or valve 60. Air is accordingly drawn in through inlet manifold 40 and inlet openings 44, along adjustable gap 48 adjacent the back surface of the silicon carbide front wall 28 so as to

flow longitudinally of the direction of draw, and outwardly through outlet openings 50 and exhaust ducts 54. In view of the fact that each exhaust duct 54 is provided with an individually controlled valve or gate 56, and since each duct is in communication with one outlet opening 50 extending across a predetermined area of the width of housing 10, it is possible selectively to control the amount of air passing over various horizontal portions of the front wall 28. That is, since the edge portions of the newly formed sheet glass are normally thicker than central portions due to forming characteristics, it is necessary to apply more cooling along the edge portions to compensate for the greater volume of glass therealong and produce even cooling along the full width of the sheet. Thus, valves 56 in exhaust ducts 54 along outer edges of the sheet are adjusted to a more open position than the centrally located ducts 54, to thus provide more cooling air along the back surface of front wall 28 adjacent the edges of the sheet S.

It will be understood, of course, that this is merely one illustration as to how the air velocity may be adjusted across the width of the back surface of front wall 28 to provide uniform cooling across the width of the sheet. The individual valves 56 may be adjusted to compensate for other irregularities, such as a wedge effect in the sheet, where the opening of each valve would be adjusted commensurate with the thickness variation in the wedge, with a small valve opening providing a relatively small amount of air to the area adjacent the apex of the wedge, and a larger valve opening providing a relatively large amount of air to the area adjacent to the thickest portion of the wedge.

The cooling of the glass is effected by the radiation of heat from the sheet to the front surface of wall member 28 and the effective removal of such heat from the wall member by the passing of the controlled high velocity stream of air across the back surface of the wall member. The wall member is accordingly made of a material having high emissivity so as to absorb the radiant heat from the glass sheet, high thermal conductivity so as to readily transfer such absorbed heat to the back surface for quick removal, and low thermal expansion so as to avoid buckling and maintain a continuous smooth surface exposure to the sheet glass.

The thickness of flow passage 48 within the confined space 38 of each housing 10 is adjustable to change the velocity of air passing over the back surface of the front wall 28, by moving heater block assembly 46 inwardly and outwardly along rails 66 by means of adjustment screws 84. Accordingly, for higher glass pulls, in which a greater volume of glass must be cooled within a given time period, the overall cooling rate may be increased by increasing the velocity across the back surface of the front wall 28 either by reducing the thickness of gap 48 by means of adjustment screws 84, or by increasing the velocity through the system by further opening main blast gate 60. Although the heater portion 72 is not deemed to be absolutely necessary to the operation of the device, the heating elements 74 are advantageous for supplying heat to the transition zone should a glass breakage occur, and also to facilitate the initial bringing in of the system at start-up time.

Although it will be readily apparent that the operation of the device would be obvious to one skilled in the art from the above description, the following specific example is illustrative of the operation. A pair of air cooled-transition housings having silicon carbide front walls about 1 inch thick were positioned approximately 5 inches on opposite sides of a glass draw line with each front wall extending horizontally about 3 inches beyond each edge of the drawn sheet and forming a transition zone about 20 inches high. A gap of .1 inch was provided within each air cooled transition housing between the back surface of the front wall and the front surface of the heater block assembly, and air at room temperature was drawn through the confined space within the housings at a rate of 700 cubic feet per minute. Glass sheet flowing at a rate of 1,550 pounds per hour was cooled by the air transition housings at the rate of approximately 15,000 BTU's per hour with the various valves in the exhaust ducts being adjusted to maintain substantially uniform cooling across the width of the sheet.

Although the invention has been described in connection with a downdraw glass drawing process in which the sheet may be formed either by an orifice structure or a forming wedge, it will be apparent that the invention is equally applicable to an updraw sheet forming operation. Further, although it is preferred to utilize a negative pressure system in the air transition housings for drawing the cooling air therethrough so as to avoid undesirable air leakage into the air transition zone which may deleteriously effect the glass, positive pressure may be utilized if adequate measures are taken to prevent air leakage into the transition zone. In addition, although it is preferred to flow the air through the adjustable passage within the confined space in a longitudinal direction which is counter to the movement of the sheet glass, a flow concurrent with the direction of draw may be utilized if a countercurrent flow is impractical. Since the air transition housings are individually con-

trolled, it is within the scope of the present invention to provide a plurality of stacked air transition housings on opposite sides of newly formed sheet to adjustably control the conditioning of the sheet in a manner similar to an annealing lehr, thereby eliminating the need for a conventional annealing lehr.

WHAT WE CLAIM IS:—

1. A method of rapidly and controllably cooling newly formed sheet glass drawn from a melt into a sheet in a forming zone and transferred while still at an elevated temperature to a transition zone wherein a flow of high velocity cooling air is passed within a confined space behind a wall member composed of a material having high thermal conductivity and emissivity and low thermal expansion spaced apart from and extending across the width of the newly formed sheet of glass, the flow of cooling air being in a direction which is longitudinal to the draw of the glass sheet, and in which the rate of air flow can be varied in different segments across the width of the confined space if required.

2. A method as claimed in claim 1 wherein the velocity of the flow of cooling air passing behind the wall member is varied by varying the width of the confined space provided immediately behind such wall member.

3. A method as claimed in either preceding claim wherein the cooling air flows through the confined space in a direction countercurrent to the direction of draw of said sheet glass.

4. A method as claimed in any preceding claim wherein the cooling air is drawn through the confined space so as to maintain a sub-atmospheric pressure therewith relative to the forming zone.

5. A method as claimed in any preceding claim wherein a plurality of outlet flows are provided across the width of the confined space and the rate of each outlet flow is independently regulated.

6. A method of cooling newly formed sheet glass substantially as described herein, with reference to the accompanying drawings.

7. An apparatus for carrying out the method claimed in claim 1 comprising means for providing a high velocity stream of cooling medium, means for varying the velocity of the stream of cooling medium and a housing which is positioned in a transition zone so as to be adjacent a surface of newly formed glass, after it has been removed from a forming area and which has a wall member arranged to face the newly formed sheet glass and which is composed of a material having high thermal emissivity and conductivity, and low thermal expansion, the back surface of the wall member and the housing forming a confined passage for the cooling medium stream across a width commensurate with the width of the newly formed sheet glass.

8. An apparatus as claimed in claim 7 wherein the housing has inlet openings and outlet openings for the cooling medium, the outlet openings being connected with means for conveying the cooling medium through the confined passage in a direction countercurrent to the direction of draw of the sheet glass.

9. An apparatus as claimed in claim 8 wherein the outlet openings are connected with a series of outlet ducts across the horizontal width of the housing, each of the ducts being provided with valve means for regulating the flow of cooling medium through a horizontal segment of the confined passage.

10. An apparatus as claimed in any one of claims 7 to 9 wherein the housing has adjustable means for varying the thickness of the confined passage.

11. An apparatus as claimed in any one of claims 7 to 10 wherein the housing contains heating means for providing heat to the transition zone during start-up.

12. An apparatus for cooling newly drawn sheet glass substantially as described herein, with reference to the accompanying drawings.

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1354006 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

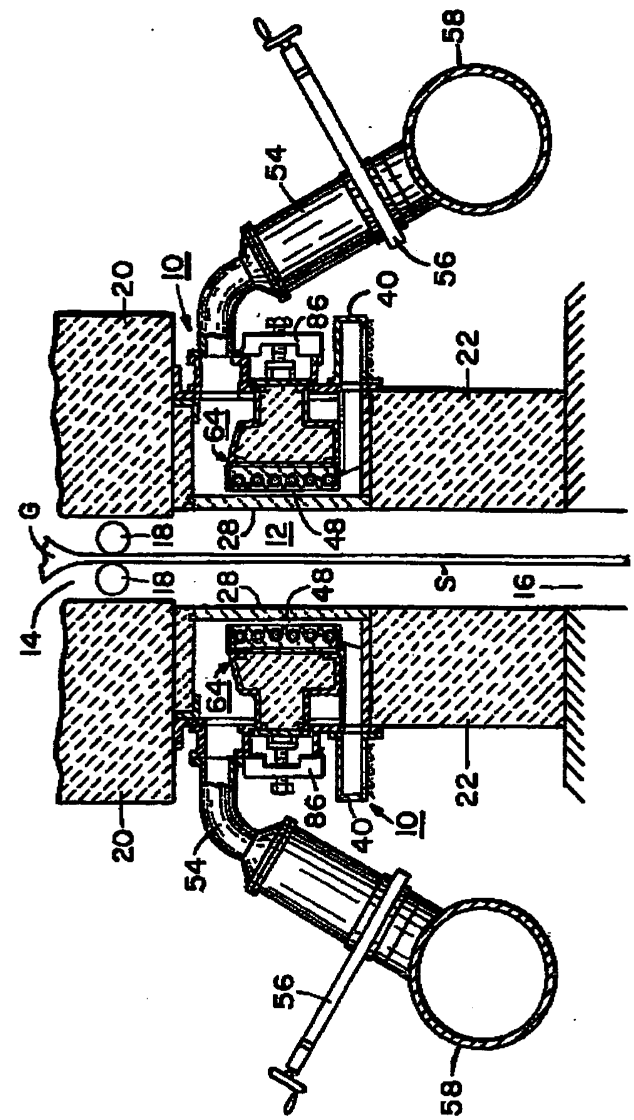

Fig. 1

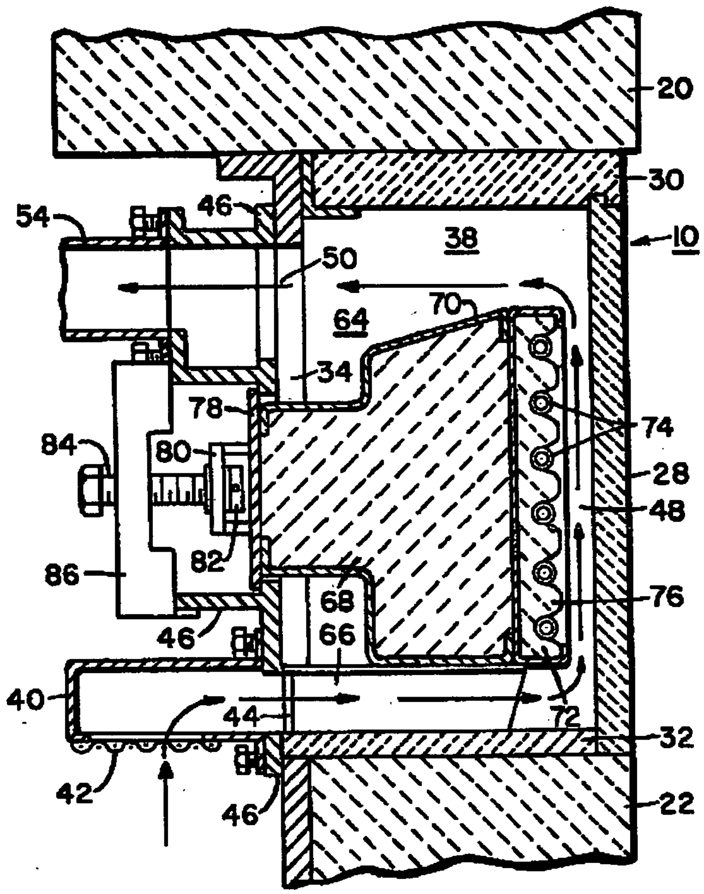
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Fig. 2

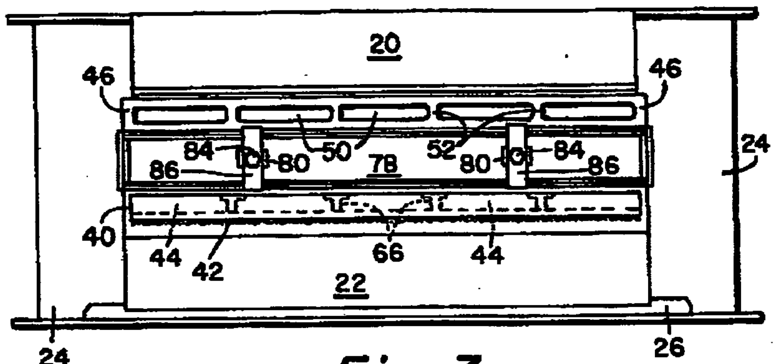
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Fig. 3

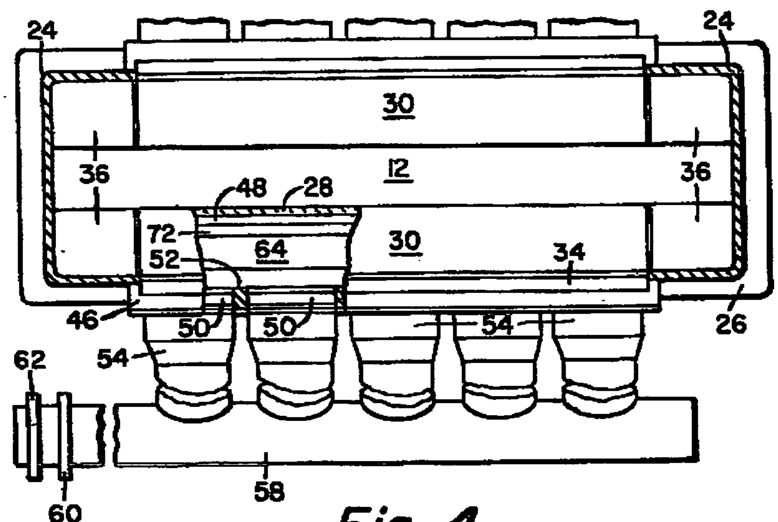
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Fig. 4